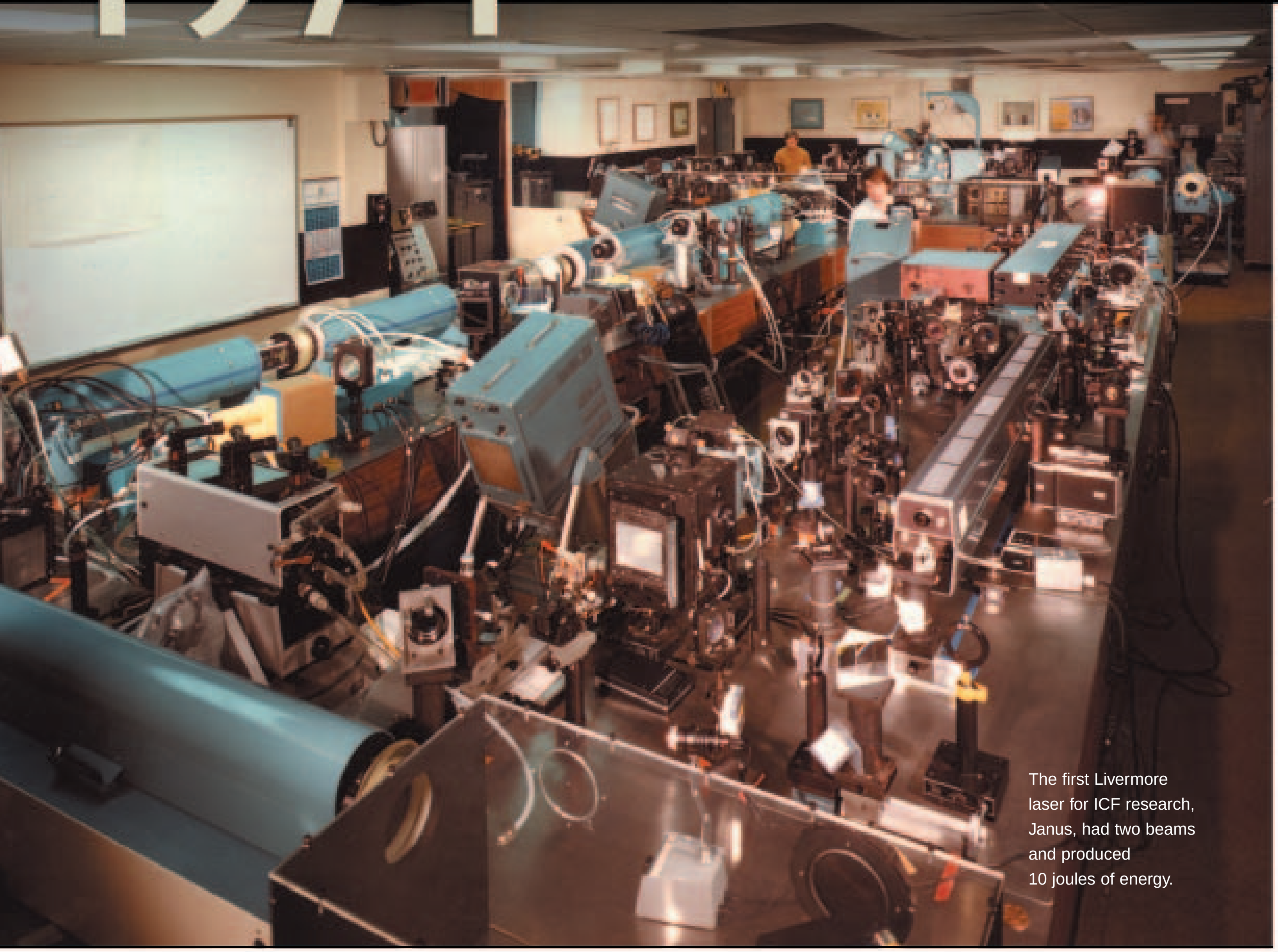
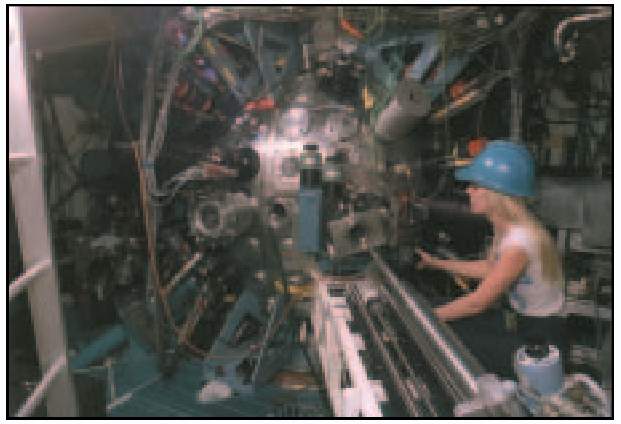


The first Livermore laser for ICF research, Janus, had two beams and produced 10 joules of energy.



With the 20-beam Shiva laser in 1977, the Laboratory established its preeminence in laser science and technology.

Lasers Join the Quest for Fusion Energy

With the goal of achieving energy gain through inertial confinement fusion (ICF) as its mission, the Laser program constructed its first laser for ICF experiments in 1974. Named Janus, the two-beam laser was built with about 100 pounds of laser glass.

Under the leadership of John Emmett, who headed the Laser program from 1972 to 1988, researchers used Janus to gain a better understanding of laser plasma physics and thermonuclear physics and to demonstrate laser-induced compression and thermonuclear burn of deuterium–tritium. It was also used to improve the LASNEX computer code developed for laser fusion predictions. Janus was just the beginning of the development, in quick succession, of a series of lasers, each building on the knowledge gained from the last, moving toward the National Ignition Facility (NIF) under construction today. The pace of laser construction matched the growth in ICF diagnostics capabilities, computer simulation tools, and theoretic understanding.

In 1975, the one-beam Cyclops laser began operation, performing important target experiments and testing optical designs for future lasers. The next year, the two-beam Argus was built. Use of Argus increased knowledge about laser–target interactions and laser propagation limits, and it helped the ICF program develop technologies needed for the next generation of laser fusion systems.

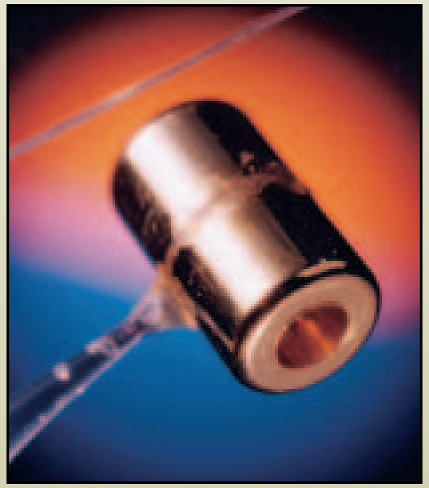
The $25-million 20-beam Shiva became the world's most powerful laser in 1977. Almost the size of a football field, it delivered 10.2 kilojoules of energy in less than a billionth of a second in its first full-power firing. Two years later, Shiva compressed fusion fuel to a density 50 to 100 times greater than its liquid density. Shiva provided more power, better control over conditions, higher temperatures, and greater fuel compression than any previous laser.

The Novette laser came on line in 1983 as a test bed for the Nova laser design and an interim target experiment facility. It was used to demonstrate the efficient coupling of higher-harmonic laser light to fusion targets and to create the first soft-x-ray laser. The Nova laser (see Year 1984), 10 times more powerful than Shiva, was built the following year.

Altogether, six large fusion laser systems were engineered and built in 10 years. The next decade of ICF research was devoted to studying and demonstrating the physics required for fusion ignition and gain (fusion output greater than energy input). The work prepared the Laboratory to take the next major step, construction of the 192-beam National Ignition Facility (see Year 1997), where scientists expect to achieve fusion ignition and energy gain.

Inertial Confinement Fusion

In a fusion reaction, two nuclei—deuterium and tritium—collide and fuse together, forming a heavier atom and releasing about a million times more energy than in a chemical reaction such as fossil fuel burning. The nuclei must travel toward each other fast enough to overcome electrostatic forces. Thus, the fuel's temperature must be over 10 million kelvins, and the fuel must be compressed to a density 20 times greater than that of lead. Laser beam light heats the surface of the fuel pellet and rapidly vaporizes its outer shell, which implodes the inner part of the fuel pellet and reduces it in size by a factor of 30 or more—equivalent to compressing a basketball to the size of a pea.



Side view of a typical hohlraum for the Nova laser shown next to a human hair. Hohlraums for the National Ignition Facility will have linear dimensions about five times greater than those for Nova.